Synthesis and Integration of Recent Research Characterizing the Carbon Cycle of Northern Eurasia

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Abstract

Rapidly rising temperatures across northern high latitude lands threatens to accelerate climate change through the release of carbon from permafrost soils and ubiquitous lakes and surface waters. Northern Eurasia is characterized by large carbon storages and seasonal fluxes, through both sinks and sources, and is thought to be particularly susceptible to climatic change. This project centers on a synthesis of data characterizing carbon cycling across the North Eurasian Earth Science Partnership Initiative (NEESPI) region, focused around numerical models capable of estimating the magnitude, potential future changes, and associated uncertainties in carbon sinks and sources. Efforts to date have involved (i) establishing contacts with collaborators and assembling data sets relevant to the project's goals and (ii) performing updates to the VIC model which will allow regional scale simulations of carbon fluxes. Here we describe the project and a preliminary analysis of net primary productivity from several available data products.

Project Collaborators and Data Sets

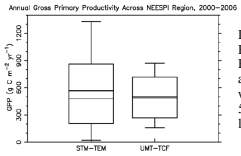
Data from previously funded NASA Carbon Cycle Science projects are central to our synthesis. Preliminary results at right are drawn from data produced in association with projects 2, 3, and 5.

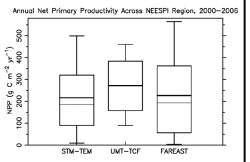
Table 1. Recent NEESPI projects focused on carbon cycle dynamics.

Principal Investigator	Project Title
Guido Grosse, *University of Alaska*	1) Assessing the spatial and temporal dynamics of thermokarst and related carbon cycling in Siberia and Alaska
John Kimball, *University of Montana*	2) Regional Assessment of Arctic Vegetation Productivity and soil respiration environmental controls using MODIS and AMSR-E: A New Approach for Satellite Monitoring of Pan-Arctic Terrestrial Net CO2 Exchange
David McGuire, *University of Alaska*	3) Synthesis of Arctic System Carbon Cycle Research through Model-Data Fusion Studies
Dennis Lettenmaier, *University of Washington*	4) Diagnosis and prognosis of changes in lake and wetland extent on the regional carbon balance of northern Eurasia
Hank Shugart, *University of Virginia*	5) Modeling the carbon dynamics of the Eurasian Boreal Forest
Vladimir Romanovsky, *University of Alaska*	6) Permafrost Dynamics within the Northern Eurasia Region and Related Impacts on Surface and Sub-Surface Hydrology

Synthesis of Model Estimates of Primary Production

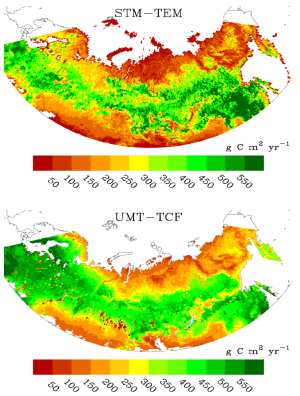
Analysis of a subset of data products shows good agreement in mean GPP and NPP. Shown here are estimates from: a modified version of the linked Soil Thermal Model-Terrestrial Ecosystem Model (STM-TEM, Hayes et al., 2011); a Terrestrial Carbon Flux model (UMT-TCF, Kimball et al., 2009) which leverages MODIS NDVI and MERRA reanalysis surface meteorology; and the FAREAST model (Shuman et al., 2011), which simulates forest demographics and dynamics as a function of climate and nutrient availability.



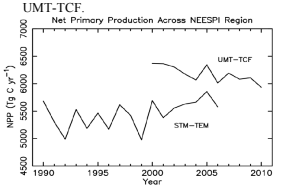


Distributions of Gross Primary Productivity (GPP, left) and Net Primary Productivity (NPP, right) across NEESPI region. Boxes and whiskers show 95th, 75th, 25th, 5th percentile values. Thick (thin) line is mean (median).

Net Primary Productivity across NEESPI region from the three models.

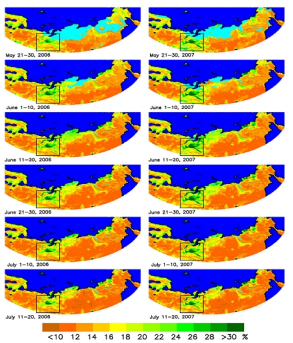


Total annual Net Primary Production across the region in Tg each year from STM-TEM and UMT-TCF.

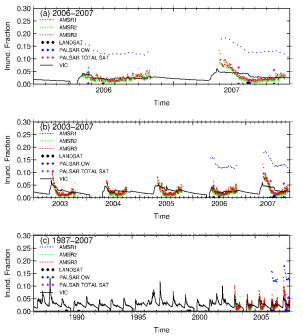


Inundated Area from Microwave Remote Sensing

Remote-sensing product (Schroeder et al., 2010) is derived using land-cover end-members present in a given scene observed by AMSR-E and QuickScat. Daily inundated area estimates (left) are used to calibrate VIC simulated fractional inundation (right).



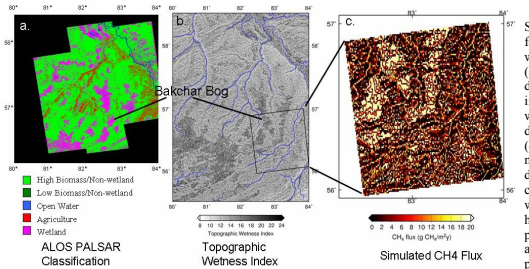
Fractional open water coverage from AMSR-E-based product.



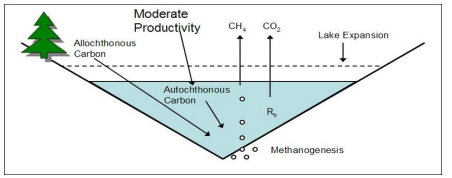
Comparison of alternative AMSR-E-based open water extent and other products with VIC model-based estimates over northern Eurasia.

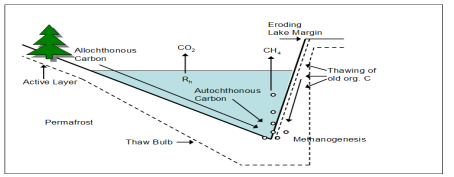
Numerical Modeling of Lake/Wetland Methane Emissions

Methane fluxes from thermokarst lakes represent a potentially significant source of carbon as the climate warms. Estimates of methane sourcing from individual lakes must be scaled up or modeled in order to understand this carbon source at regional scales. We are using a modified version of the Variable Infiltration Capacity model (VIC) modified to include fast vegetation dynamics via the BETHY model of Knorr and Heimann (2001a; b), and refinement of the lakes and wetlands module following Bowling et al., 2010.



Simulated methane emissions for the Bakchar Bog area of western Siberia.
(a) Landcover classification derived from ALOS/PALSAR imagery. (b) Topographic wetness index for the region, derived from SRTM-30 DEM. (c) Annual average simulated methane emissions for region demarcated in panel (b). Note correspondence among areas of wetland in panel (a), areas of high index values (>= 18) in panel (b) and areas of high annual methane emissions in panel (c). Graphic from Bohn et al (2007).





VIC model schematics for lakes not underlain by permafrost (upper), and those underlain by permafrost (lower). Arctic lakes receive substantial subsidies of *allochthonous* carbon, or carbon from the surrounding landscape. In addition, in lakes underlain by permafrost, ancient carbon trapped in the frozen soil can be released as the soil thaws, providing another input of carbon to the system.

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